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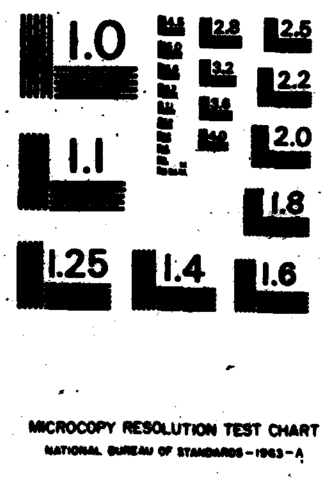
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FOREIGN TECHNOLOGY DIVISION

RE-ENTRY AND SIMULATION

by

H. Jian and X. Guangming

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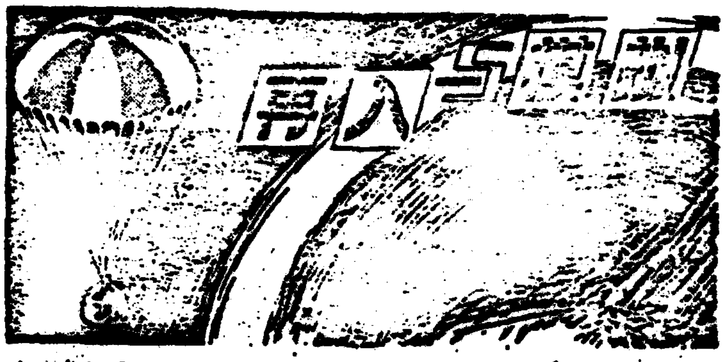


Re-Entry and Simulation

Hou Jian and Xu Guangming

As science and technology continue to develop, in recent years many space tests have taken place each year. As the news broke out, people naturally are joyful about these great advantages of the human race. People more or less have some understanding about their launching and orbiting due to the continuous introduction in the newspapers and magazines. But, do you know how these flight vehicles (war heads, satellites, or spacecrafts) can re-enter the atmosphere to return to the surface of the earth? In addition, do you know the various simulated tests carried out by the scientific workers in order to clear the obstacles in re-entry?

Re-entry

As we know, the warhead of a guided missile finally must re-enter the atmosphere, after being launched by the rocket into the space, to reach its target on the ground (Figure 1). Spacecraft and other flight vehicles are also similar. It is necessary to bring the astronauts and the data collected in the universe back to the ground safely. Here, to "re-enter the atmosphere" is called re-entry.

Re-entry, does not seem to be a problem at all from a rough viewpoint. This is because it is not very difficult for a naughty boy to throw a stone down from the top of a skyscraper. Aircrafts have been used for dropping various cargoes and attached objects, which has already been acknowledged as a fact. Therefore, it is

easy for people to abruptly believe that the dropping of a warhead from several thousand kilometers (e.g. 2,300 kilometers) high in the sky to re-enter the atmosphere should correspond to the dropping of a heavy object from the sky, which should not be difficult at all. However, this is not the fact. If we use the altitude h = 2,300 kilometers into the simple calculation using the formula to estimate the final speed of a parabolic motion $V = \sqrt{2}gh$, we know that V = 6.7 Km/sec. It is approximately 7,000 m/sec, corresponding to 20 times of the local sonic speed (of course, the calculation of the speed of a warhead to re-enter the atmosphere is not that simple. However, this rough estimation can provide us with an order of magnitude idea.)

Figure 1(a). The Typical Trajectory of a Strategic Ballistic Guided Missile.

1. The launching segment; 2. End of the third stage thrust; 3. Releasing the individually guided multiple warheads and starting the measures to penetrate the defense system; 4. Trajectory; 5. Re-entry segment; 6. Earth.

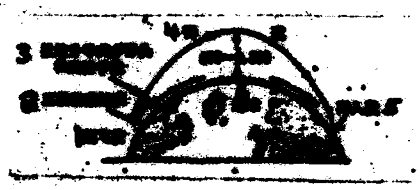
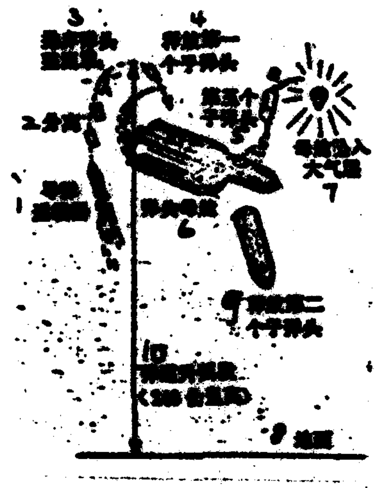


Figure 4. Schematic Diagram of the Typical Lifting Acceleration Segment Test.

1. 68 Kilometer; 2. Ground; 3. Ignition of the first stage; 4. Ignition of the second stage; 5. Ignition of the third stage; 6. End of the three stages; 7. Separation of the load; 8. The work of the retrieval system; 9. The drop point.

Figure 1(c). Schematic Diagram of the Re-entry and Release of a Multi-Warhead Guided Missile.

1. Carrier vehicle of the guided missile; 2. Separation; 3. Discarding the flow regulating mask of the warheads; 4. Releasing the first small warhead; 5. The third small warhead; 6. The cabin containing the warheads; 7. Cabin falling into the atmosphere; 8. Ground; 9. Releasing the second small warhead; 10. The rising segment of the trajectory (240 kilometers high).



7000 meters per second is a tremendous number. When a warhead enters the dense atmosphere at such a high speed, the heat produced by the huge friction of air can turn it into ashes in several seconds. There have been precedents in nature. According to statistics, there are 10^{10} meteorites weighing from $10^{-5} \sim 10^{3}$g entering the atmosphere of the earth. However, the number reaching the ground is very few. It almost happens once every hundred years.

Someone may propose that it would be a good idea to allow the warhead to fall to the ground at a low speed. However, it is impossible for a ballistic guided missile. This is because the range, altitude, and re-entry speed of a guided missile are inter-related. In order to reach a longer range, it is necessary to launch to a high altitude. However, the higher the altitude is, the re-entry speed must be large. In addition, in order to

strengthen the capability to penetrate the defensive system, it is also desired to have the fastest falling speed possible. Thus, it is capable of attacking the opponent by surprise.

In addition to experiencing the high temperature test, the re-entry of warheads to the atmosphere is not smooth sailing all the way. There are numerous obstacles awaiting it. They include cloud and fog, rain and snow, particulates, and dusts. People always say that the weather changes abruptly. It is difficult to control ahead of time. It is even more unavoidable with regard to dusts which are distributed by people. These light small particles are inconsequential to automobiles and trains. However, for a warhead traveling at a super high speed, it is a serious obstacle. It is because of the large relative velocity between them, which consequently carries an extremely large kinetic energy. The collision between them will accelerate the combustion and erosion of the warhead.

Another problem, which is not considered as an obstacle, is the creation of the so-called plasma sheath shield when the warhead enters the atmosphere at a high speed. It is a phenomenon due to the decomposition, dissociation, and ionization of air. The plasma sheath covers the entire warhead, like a meteorite, it has a long tail. It not only affects the radio communication between the warhead and the ground, but also greatly increases the radar reflection area to provide a favorable condition for the enemy to identify. In summary, the re-entry of a warhead into the atmosphere is not as easy as throwing a stone. Instead, there are /27
many obstacles and there are many problems.

Figure 1(b). The Types of Motion of the Warheads During an Attack Against the Target Upon Re-entering the Atmosphere.

1. Assisted gliding re-entry; 2. Mobil trajectory re-entry; 3. The multiple warhead individually guided re-entry flight vehicle after releasing the small warheads; 4. Multiple warhead individually guided re-entry; 5. Ballistic re-entry; 6. Ground target.

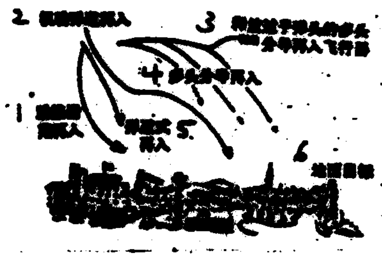


Figure 3. Schematic Diagram of the Aircraft Launched Free Flight.

1. Launching Condition: altitude 17 kilometers, velocity 400 m/sec, inclination angle 31°; 2. Ignition of the First Stage: altitude 19 kilometers, angle of inclination -9.5°; 3. Ignition of the second stage; 4. Work completed in the first stage; 5. Work completed in the second stage, altitude 14 kilometers, velocity 4 Km/sec, inclination angle -15.5°; 6. The ground; 7. 47 kilometers.

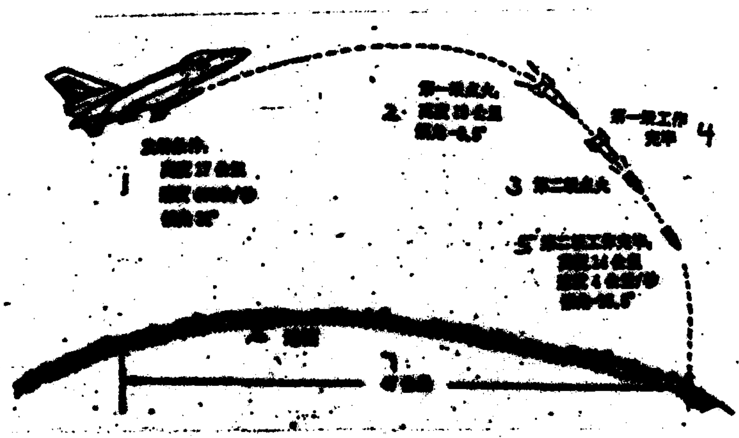
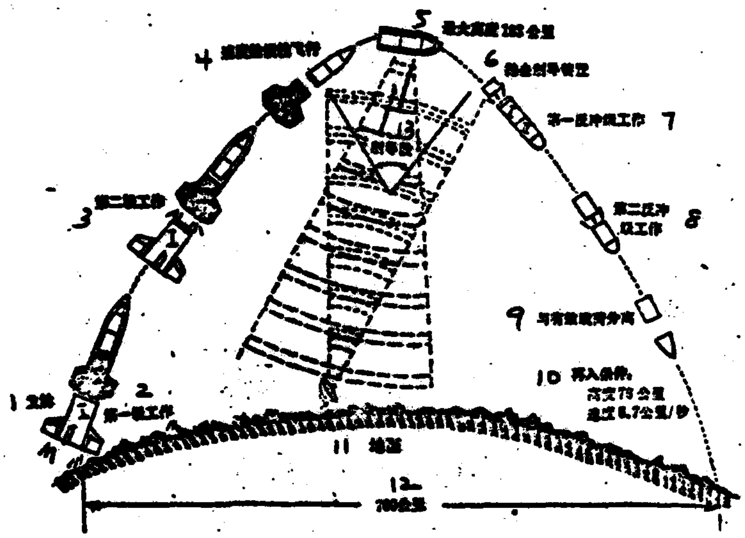


Figure 2. Schematic Diagram of the Free Flight of Special Trajectory.

1. Launching; 2. First stage work; 3. Second stage work; 4. The velocity cabin in an inertia flight; 5. Maximum altitude 183 km; 6. Discarding control and guidance equipment; 7. First recoil stage work; 8. Second recoil stage work; 9. Separation from effective load; 10. Re-entry conditions: altitude 76 kilometers, velocity 6.7 Km/sec; 11. The ground; 12. 760 kilometers; 13. The controlled and guided section.



Simulation

In the development of astronautical weapon systems, in order to adapt to the complex environment of the modern war, the first thing to solve is the re-entry problem so that it is possible to ensure that the warheads can safely be deployed over the target. Next, it is necessary to improve its capability to penetrate the defense and to increase the destruction to the extent possible. To successfully resolve these problems, it involves many disciplines centered around aerodynamics. Therefore, before the success of each astronautical technology, the scientific and technical workers must perform a great deal of theoretical studies and carry out various simulation tests.

Currently, the three major experimental techniques commonly used are the computer, the wind tunnel, and the free flight. By practice, it has been proven that computer simulation has an active effect on the study of the re-entry problem. It not only has a fast speed, but also costs less. A wind tunnel is an important experimental means in the development of aircrafts. In the meantime, it is also an indispensible piece of simulation equipment for other flight vehicles. In the recent twenty to thirty years, the wind tunnel technology has obtained rapid development. It is not only capable of simulating the high speed condition of up to a M number above 20, but also able to simulate the high altitude conditions during the re-entry through other auxiliary equipment. In the meantime, it is not affected by the weather and is convenient for repeated testing.

The free flight simulation test (or as called, the sky simulation) is to fly a model of the flight vehicle in a similar atmospheric environment as the flight vehicle through launching in the sky or from the ground. Furthermore, external measurements, remote measurements, and data retrieval methods are used to obtain various types of data. Because the model size is relatively large, the environment is close to real and the comprehensive simulating capability is high, therefore, this method has an important effect on the development of the entire astronautic industry. Presently, the free flight simulation tests mainly include the special trajectory simulation test (see Figure 2), the air-launched simulation test (see Figure 3), and the test utilizing the lifting section of the trajectory (see Figure [illegible]).

The three major simulation testing methods have their own advantages and disadvantages. [illegible] to take [illegible] industry.

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it has already been proven that the maximum temperature can reach to 7,000 ~ 8,000 degrees when the warhead re-enters. At such a high temperature, if aluminum, which is the skin of an aircraft, is used as the shell of the warhead, it will behave like a piece of paper and get burnt in no time. Even a steel plate is not much better. Back then, there was almost no suitable material to be used. Since the fifties, people have tried many ways to explore a method to resist the heat. In the early sixties, a new technology to prevent heating had emerged. A special material is used as the shell. When the warhead re-enters the atmosphere, it is allowed to burn off a part of the shell. The burnt portion removes a great deal of the heat. This technology made the re-entry of warheads successful. In the late seventies, a new heat resistant structure - the heat resisting tile had emerged. It has already been successfully used on the space shuttle. With regard to the air-borne particles, these heat resistant materials also have some active effects.

Science continues to advance. The mankind has already begun the march towards the universe. In the path of the future conquering of the universe, simulation tests are still the pioneers in search for a solution to clear the road.

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